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ABSTRACT

The experiment reported was designed to determine whether programed material low in response contingency, and thus yielding a high blackout ratio, is read less thoroughly than programed material heavily response contingent and yielding a low blackout ratio. Eye movements were compared for two parallel forms of the same program, differing only in the choice of omitted word. In one version the response was relatively unrelated to the rest of the item (65 percent blackout ratio); in the other the response depended on more of the material (25.4 percent blackout ratio). Subjects were 18 college students who received half their material from the high and half from the low blackout program. Half of the subjects received the initial material in high blackout form. Eye movements were recorded by a Mackworth Eye Marker Camera. High blackout ratio material (low response contingency) resulted in fewer fixations, shorter fixation time, and shorter scanning time than did low blackout ratio material. It was concluded that high blackout ratio programs fail to evoke the students' attention. Tables, graphs, and references are included. (Author/WB)

EYE MOVEMENTS AS A FUNCTION OF RESPONSE CONTINGENCIES MEASURED BY BLACKOUT TECHNIQUE[1]

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Abstract

The experiment determined whether programmed instruction material low in response contingency, and thus yielding a high blackout ratio, is read less thoroughly than programmed material heavily response contingent, and yielding a low blackout ratio. Eye movements were compared for two sets of material which were parallel forms of the same program differing only in the choice of omitted word. In one version the response was relatively unrelated to the rest of the item (65% blackout ratio) while in the other the response depended on more of the material (25.4% blackout ratio). Eighteen subjects received half their material from the high and half from the low blackout program. A counterbalanced design provided for half the subjects to have the initial material in low blackout form and half the subjects to have the initial material in high blackout form.

Location and duration of all eye fixations in each item were recorded by a Mackworth Eye Marker Camera. High blackout ratio material (low response contingency) resulted in fewer fixations, shorter fixation time and shorter scanning time than did low blackout ratio material. Both the eye movement analysis and the previously found poor posttest performance on high blackout-ratio programs demonstrate that such material fails to evoke the student's attention.

EYE MOVEMENTS AS A FUNCTION OF RESPONSE CONTINGENCIES MEASURED BY BLACKOUT TECHNIQUE[1]

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All too familiar are the self-instructional programs that require little of the student, teach him little, and bore him much. These often are programs with responses prompted by trivial cues rather than the core material which should be learned. Proper programming requires not only a low error rate but requires that the reinforcement (e.g. reaching a correct answer) follow some activity that is to be established. The blackout technique was developed to provide an index of the degree to which verbal material is programmed in the sense that answering correctly depends on observing the rest of the item (cf. Holland, 1967). When much material can be obliterated without affecting error rate (a high blackout ratio) then relatively little is learned in the program (Holland & Kemp, 1965), and the question of whether responding is overt or covert is unimportant (Kemp & Holland, 1965). In programmed, or non-blackoutable, material a response is contingent upon, i.e., depends upon, using the material in some way. It must at the least be read. In fact, in relatively unprogrammed material having a high blackout ratio, it is possible that the poor learning and irrelevance of response mode may result from students answering correctly without even reading much of the material.

The present study was designed to determine whether material low in response contingency, and thus yielding a high blackout ratio, is read less thoroughly than material heavily response contingent and yielding a low blackout ratio. To do so, eye movements were compared for two sets of material of different blackout ratios. Actually, the two sets of material were two forms of the same program which varied only in the choice of omitted word. In one, the response blank was chosen so that the response was relatively unrelated to the rest of the item (65% blackout ratio) while in the more adequately programmed other version the response depended on more of the material (25.4% blackout ratio). If, when these programs are presented in their normal (non-blacked out) form, the higher blackout-ratio program evokes fewer eye movements, it would confirm the supposition that the relatively unprogrammed material may not even be read carefully. These two forms of the program were used in previous demonstrations of the importance of low blackout ratio for adequate posttest performance and the importance of overt responding on a low blackout ratio program; therefore, eye movement difference in this study would tend to indicate that the difference in programmed and unprogrammed material is in the failure to engage in behavior unless it is required as precursory for the correct response.

Method

Subjects

Eighteen college students from Introductory Psychology classes served as subjects. All of them were able to read a display like those used in the experiment without glasses or contact lenses.

Subjects received credit for experimental participation required of Introductory Psychology students at the University of Pittsburgh. In addition, they earned an amount of money based upon both speed and accuracy of response.

Materials

The material in the experiment proper consisted of 120 completion items, Sets 7, 8, 9, 10, from The Analysis of Behavior (Holland & Skinner, 1961). These sets were chosen in preference to earlier sets because the necessary experimental alterations had been made for an earlier experiment (Holland 1960, 1964), and blackout ratios had been calculated and experimentally verified (Holland & Kemp, 1965). There were two versions of Sets 9 and 10. A normal version has a blackout ratio of 25.4% and an altered version has a blackout ratio of 65%. The altered version was similar to the normal except that the original blank was completed and another word was left blank which rendered the response dependent on use of less of the item. See Table 1 for examples. Additional

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Insert Table 1 about here

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material included a thirty-item segment of a banking program, a high blackout-ratio program (69%, cf. Holland & Kemp, 1965) with particularly pronounced segregation of contingent and non-contingent material.

Each item was separately photographed and presented with a 35mm carousel projector onto a translucent 7 1/2-inch square screen, 28-inches from the subject. Negatives were used giving light letters on a dark background to decrease the unpleasant glare. No item

exceeded the bounds of a visual angle of 15° ; each letter was approximately 3/4° visual angle in height with 1° visual angle between word.

Apparatus

A Mackworth Eye Marker Camera (Polymetric Products, Model V-1164) recorded the eye movements in the form of a motion picture of a light spot reflected from the subject's left cornea and the display. When the system is properly calibrated, the light spot is superimposed on the image of the display at a point corresponding to the point of fixation (Mackworth, 1967).

Procedure

Position of the subject in the apparatus. The subject was seated in a dental chair, his forehead rested on a brace, and his teeth were secured in a bite board covered with a dental wax impression of his teeth. His arms were folded on a ledge in front of him. Adjustments were made to obtain maximum comfort while maintaining a steady body and head position.

Calibration of the optical system. A slide containing five digits, one in the center and one in each corner, was used for calibration. The subject was instructed to fixate the center digit. The system was brought into focus, then adjusted laterally and vertically until the reflected light spot was directly upon the center digit. The subject was then asked to fixate each corner digit after which further adjustments were made, if necessary. Since the subject removed his mouth from the bite board to give his response, recalibrations on this type of slide were made after every item.

Introduction of the subject to the task. The subject was next instructed in the use of his control buttons. One button opened a

shutter exposing the slide and started the motor of the movie camera and another closed the shutter and stopped the camera. The subject then pressed Button 1 and received item 1 (Set 7 of The Analysis of Behavior) as a sample item. As soon as he was prepared to respond, he pressed Button 2 and released the bite board. He said his answer out loud, which was recorded by the experimenter, and was then told to again press Button 1. This button press exposed a confirmation slide giving the correct answer. The next slide was a calibration slide. During the confirmation slides and the calibration slides, a small foot pedal controlled by the experimenter prevented the movie camera from operating.

Preliminary training. Each subject began with Set 7 and 8 of The Analysis of Behavior. For these sixty items, the subject was told that he would be paid five cents for every correct answer regardless of the time spent viewing the slide. This was done to accustom the subject to the material and the apparatus. No penalty was in effect for wrong answers at this time. No subject was kept longer than these first sixty items during the first session, but only half of the subjects completed the entire sixty items in one session. One week elapsed before the subject returned to the testing room whether or not he had finished the preliminary training.

Experimental testing. The subjects were divided into two groups. Half received the normal version of Set 9 (30 items) and the altered version of Set 10 (30 items), the other half received the altered version of Set 9 and the normal version of Set 10. This counterbalanced design aided in the control of individual differences in reading speeds and styles. Each subject was presented with a high and a low black-out-ratio program.

During experimental testing, a variable incentive system encouraged speed. Table 2 presents the scale of payment for correct

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Insert Table 2 about here

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responding. The penalty for an incorrect response was a subtraction of three cents from the subject's earnings. The experimenter monitored a clock and informed the subject of how much he earned or lost after each item. Earnings ranged from $3.45 to $6.29 with an average of $4.78.

Additional testing. After completing Sets 9 and 10, all subjects were immediately given the thirty-item segment of the banking program under the same scale of payment and penalty as the experimental testing.

Results

From the photographic film, data were obtained on the number and location of eye fixations per item for each subject, the average duration of fixation, and the average viewing time. Occasional calibration shifts caused incomplete data for some subjects. The subject means therefore represent different numbers of items. A chi square test performed on the total frequencies for each cell was not significant; nor was there any other reason to suspect that data missing due to calibration drift was in any way differentially related to groups or conditions.

Number of Eye Movements

The major results were as expected. (See Figure 1). On

Insert Figure 1 about here

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the version with a low blackout ratio, there was a larger number of eye movements than the corresponding altered version which has a higher blackout ratio. The means for the two sets with low blackout ratios were 13.73 and 11.58 fixations per item (S.D. 8.95 and 9.54, respectively) as compared to the means for those two sets when the blackout ratio was high, 8.48 and 8.92 fixations per item (S.D. 9.91 and 7.21, respectively). The difference in number of fixations as a function of blackout ratio proved statistically significant ($p < .001$) in a repeated-measures analysis of variance. In Figure 1, there would appear to be an interaction between blackout ratio and the order in which the subjects experienced material of high and low blackout ratios. Group 1 used a set with a low blackout ratio first, then a set with a high blackout ratio while Group 2 had first a set with a high blackout ratio and then a set with a low blackout ratio. Such an interaction could result if reading patterns established on one set of material partially transferred to the next set. Thus, when altered form of Set 9 is used followed by the normal, low blackout version of Set 10 the frequency of fixation is lower than expected. A less adequate reading pattern is further attested to by the high error rate (33%) for the low blackout version of Set 10 following a high blackout version of Set 9. (For contrast, other error rates were: 19% for the normal version of Set 9, and 16% and 10% for the altered version of Sets 9 and 10 respectively). However the interaction effect between order and blackout ratio fails to reach statistical significance at the .05 level of confidence ($F = 3.79$, F at .05 is 4.49). Nevertheless, the strong hint of an interaction is interesting and suggestive.

Duration of Fixation

The length of time of the single fixation was determined by counting the number of successive photographic frames with light spots

in the same location. This number is a measure of time; each photographic frame represents 167 msec. The mean duration of fixation was longer on the normal versions than the altered versions. Subjects using the low blackout-ratio versions averaged 325 msec. on Set 9 and 217 msec. on Set 10 (S. D. 25.1 and 24.6, respectively). The same subjects given versions with a high blackout ratio averaged 290 and 295 msec. (S. D. 22.4 and 22.8, respectively). This difference between high and low blackout ratios is statistically significant ($p < .001$, repeated-measures analysis of variance). For duration of fixation there is no hint of interaction between blackout ratio and order of presentation of units differing in blackout ratio. Subjects on the normal versions fixated longer regardless of order of presentation.

Total Viewing Time

The sum per item of each photographic frame containing a light spot is a measure of the total time the subject fixated the item and is a composite of number of fixations and duration of fixation. Naturally these data also differed according to blackout ratio. The subjects fixated for significantly longer periods of time on versions of low blackout ratio than on versions of high blackout ratio. Mean fixation time per item on the two normal versions were 4.52 sec. and 3.62 sec. (S. D. 7.77 and 8.36, respectively) as compared with 2.60 sec. and 2.74 sec. (S. D. 7.10 and 6.75, respectively) on the altered versions.

Discussion

Response-contingent material receives careful attention; if the subject is to answer correctly it could not be otherwise. But when less material serves as the response contingency in a high blackout program subjects fixate less of the material and for shorter periods.

High blackout material receives less attention than low blackout material. On the program with a high blackout ratio, subjects either fixated for a short duration or not at all on the non-contingent material. The data obtained from the program with the high blackout ratio showed fewer eye movements, shorter fixation duration and shorter scanning time per item than the data obtained from the low blackout-ratio program.

Location of fixation was examined using data from four selected subjects on a thirty-item segment of the banking program which each subject used after he completed the experiment proper. This program was a high blackout program with particularly pronounced segregation of contingent and non-contingent material. For each item, the ratio of fixated words critical to correct answer attainment was compared to the ratio of fixations on the remaining "unblackoutable" material. The ratio of fixations per word was higher for the critical words which could not be blacked out than for the words which were unrelated to obtaining a correct answer and therefore could be blacked out (.41 for the critical words as compared to .18 for the non-critical words). On low blackout programs a normal reading pattern is usually found with much of the material fixated; but on high blackout programs the pattern is different. The initial fixation is often at or near the response blank and later fixations suggest a search for key words and phrases. When an occasional low blackout item is embedded in an otherwise high blackout program, the initial fixation near the blank may be followed by a large number of jumps back and forth about the item in search of cues.

The hint of a detrimental transfer from performance on high blackout material to performance on low blackout material could reflect the continuation, for a time, of these eye movement patterns.

This transfer effect merits further investigation because, if substantiated in other experiments it would imply deleterious effects of high blackout ratios reaching beyond the specific material.

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Footnotes

[1]This study is based on a thesis submitted by the senior author to the University of Pittsburgh in partial fullfillment of the requirements for the M. S. degree. The research reported herein was supported by the Learning Research and Development Center supported as a research and development center by funds from the United States Office of Education, Department of Health, Education, and Welfare.

Table 1

Sample Items

(Set 9, A of B, Items 20 and 21)

Item 20.

A school teacher is likely, when possible, to dismiss a class when her students are rowdy because she has been _____ by elimination of the stimuli arising from a rowdy class.

Answer Reinforced

(negatively reinforced)

Item 20.

A school t_____ is likely, when possible, to dismiss a class when her students are rowdy because she has been negatively reinforced by elimination of the stimuli arising from a rowdy class.

Answer teacher

Item 21.

The teacher who dismisses a class when it is rowdy probably causes the frequency of rowdy behavior to 1) _____ since dismissal from class is probably a (n) 2) _____ for rowdy children.

Answers 1) increase

2) reinforcement

Item 21.

The 1) _____ who dismisses a class when it is rowdy probably causes the frequency of 2) _____ _____y to increase, since dismissal from class is probably a reinforcement for rowdy children.

Answers 1) teacher

2) rowdy

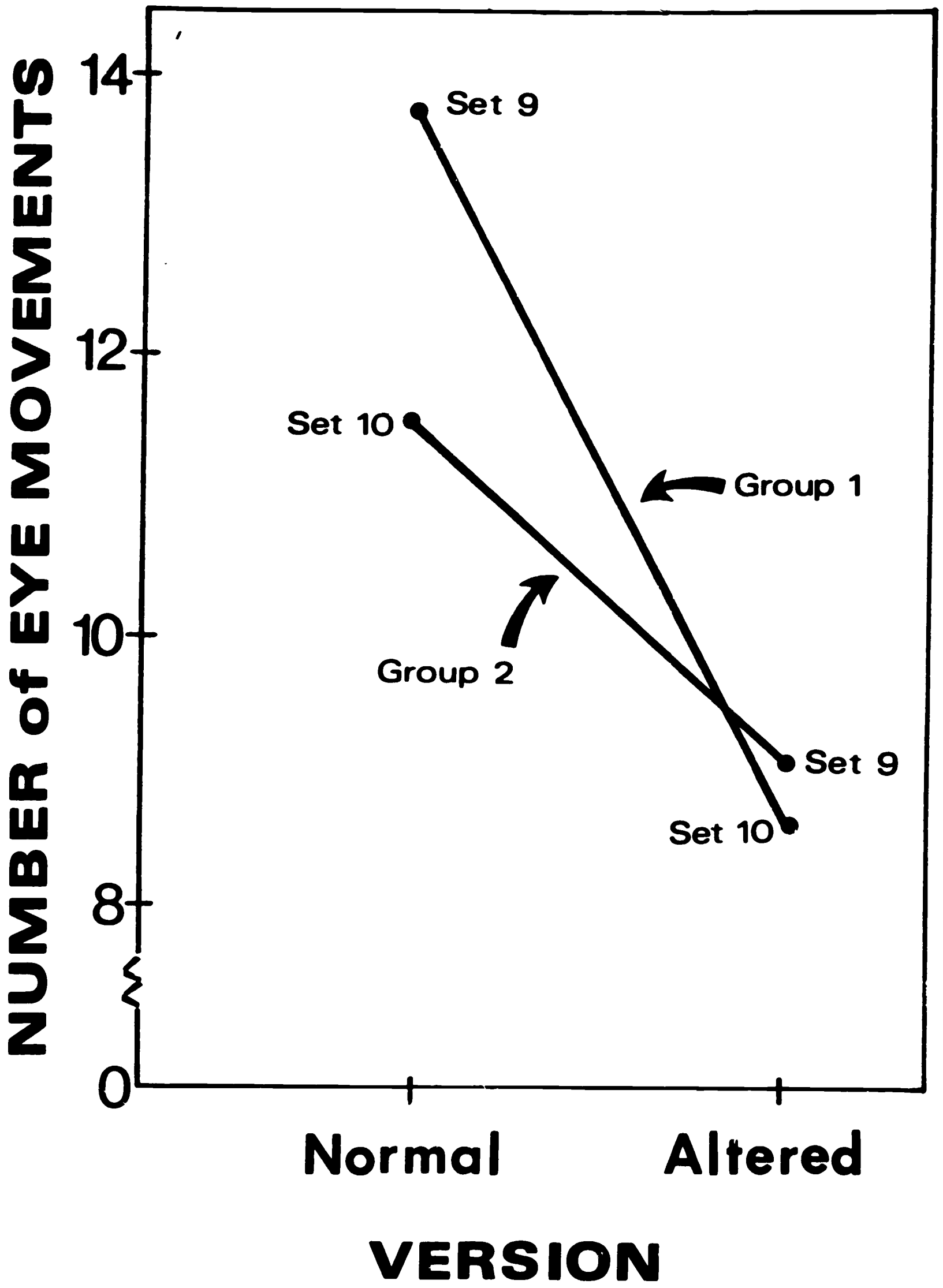
Table 2

Scale of Payment for Correct Response

Seconds (Interval between button press #1 and 2)	Cents
0 - 5	5
6 - 10	4
11 - 15	3
16 - 20	2
21 -	1

Figure Caption

Figure 1. Mean number of eye movements on the normal and altered versions.


NUMBER of EYE MOVEMENTS
14
12
10
8
0
Set 9
Set 10
Group 1
Group 2
Set 9
Set 10
Normal
Altered
VERSION